European Scientific Journal December 2013 edition vol.9, No.36 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

AEROSOL BEHAVIOUR OVER RANCHI

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Abstract

Atmospheric aerosols are important component in the radiation budget and generally tend to decrease the amount of solar radiation falling on earth. Some aerosols like BC are absorbing in the nature and affect the climate by increasing AOD and warming the climate. Its direct and indirect effect on environment and human health is partially known but more studies are needed to understand it properly. That is why it is important to do its Quantitative and qualitative analysis and study its impact on climate etc. Ranchi is comes under northern region which is most polluted region among India where many pollutants including BC are high in concentration, So this study of BC over Ranchi can help to know its concentration of BC is found to vary on a diurnal as well as seasonal basis. The role of atmospheric boundary layer is very important in the variation of BC concentration. The present study aims to find the relation of BC with the boundary layer and understand its variation. Further its impact on AOD and global radiation will also study. This research may form a small step towards a comprehensive study of black carbon aerosol in the atmosphere in the northern city Ranchi of India.

Keywords: Aerosol, black carbon

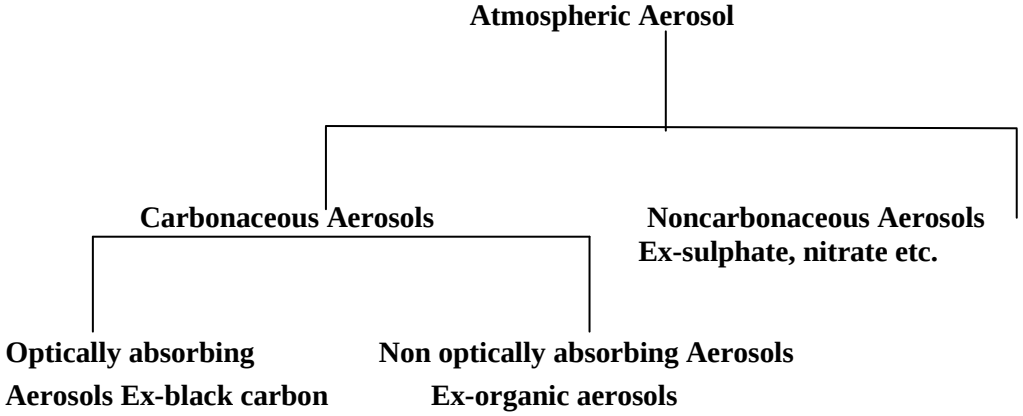
1. Introduction

Aerosols are tiny liquid or solid particles that are present in the atmosphere having diameters in the range from 1nm to over10nm.Most of the aerosol mass lies in the range from about 0.1 to 10nm.Aerosols are important atmospheric components due to their impact on air quality and because they are relatively important, affecting climate on a regional and sometimes global scale.

The net effect of aerosol on climate is to cool the surface, but depending on their absorbing properties, aerosol can also warm the

atmosphere while cooling the earth surface (Kaufman et al; 2002, Ramanathan et al, 2001).The aerosol absorption properties depend mainy on the Black carbon concentration, and on the internal vs. External mixing with non-absorbing particle (Dubovik et al., 2002, Jacobson 2001).

Black Carbon is a major component of major component of the atmospheric aerosol composition and it has a wide-ranging effect on the aerosol radiation forcing. As these aerosols are mainly absorbing in nature they change the imaginary part of the refractive index of the the atmosphere.



2. Methodology

Sampling site:

All the measurements are carried out in the premises of Birla Institute of Technology, Mesra Ranchi. It is located in northern India, which is well urbanised. The monitoring site is in the Department of Applied Mathematics, Which is approx 4km away from the main road.

Instrumentation:

a) Aethalometer
b) Satellite data (Modis)
c) Radiosonde (Dr. Pisharoty Sonde System)

a) Aethalometer: Model AE-31 of Magee Scientific, USA.

Principle

The principle of the Aethalometer is to measure the attenuation of a beam of light transmitted through a filter, while the filter is continuously collecting an aerosol sample. This measurement is made at successive regular intervals of a time base period. By using the appropriate value of the specific attenuation for that particular combination of the aerosol deposit at each measurement time. The increase in optical attenuation from one period to the next is due to the increment to the aerosol black carbon collected from

the air stream during the period. Dividing this increment by the volume of air sampled air stream during the period.

The optical attenuation (ATN) is defined as

ATN=100*ln (I0/I)

Where I0=Intensity of light transmitted through the original filter or through a blank portion of the filter

I= Intensity of light transmitted through the portion of the filter on which the aerosol deposit.

For given mass of BC, the optical attenuation at a fixed wavelength λ may be written as

ATN (λ) =σ (1/λ)*[BC],

Where [BC] is the mass of black carbon, and σ (1/λ) is the optical absorption cross-section known as specific attenuation. The measurement is affected by the wavelength of the light with which it is made, provided that the particle size is somewhat smaller than the wavelength. The general accuracy of the measurement is of the order of 5% and sensitivity is <0.1 micro grams/m3.The sampling done on automatically advancing quartz fiber filter tape.

b) Satellite Data (Modis):

The radiant energy reflected and emitted by the Earth carries a signature of the atmospheric properties as it passes through the atmosphere. Satellites sensors can quantify several atmospheric properties by measuring the wavelength, angular and polarization of this reflected and emitted energy (Kaufman et al., 2002a). MODIS has 36 bands ranging from 0.4- to 14.4- μm wavelengths with three different spatial resolutions (250, 500 and 1000 m).

MODIS measures AOD with an estimated error of ±0.05±0.20_a over the land (Chu et al., 2002) at 0.47 and 0.66 wavelengths at 550-m resolution and extrapolated to a 0.55-μm wavelength (Ichoku et al., 2002). Except for dust, effect of the aerosols on the radiance measured by satellite decreases with wavelength (Kaufman, 1993), the aerosol type has been determined from the information on the global aerosol distribution and a suitable aerosol dynamic model has been chosen to invert the measured radiance by satellites to produce aerosol data products. The detailed methodology of the retrieval of AOD has been discussed by Kaufman et al. (1997b).Aerosol particles, such as black carbon soot, are visible from space, enabling a global estimate of the presence of a variety of pollutants using satellite data.

TERRA/AQUA satellite-based MODIS instruments have been acquiring daily global data in 36 spectral bands from visible to thermal infrared. The MODIS sensor is onboard the polar orbiting NASA-EOS Terra and Aqua spacecrafts with equator crossing times of 10:30 and 13:30 local

solar time, respectively . The data used in this study include Terra/Aqua satellite-based MODIS aerosol products.

c) Radiosonde (Dr. Pisharoty Sonde System)

Radiosonde is a balloon-borne instrument used for the upper atmospheric studies typically up to altitudes of 40 km. The Radiosonde is lifted up through the atmosphere by helium or hydrogen filled balloon. A transmitter located in the radiosonde transmits the data to the ground station. The fully end to end indigenous GPS Sonde system designed and developed by RF Advanced Technology and Facilities Division (RFAFD) / RF Systems Group, Vikram

Sarabhai Space Centre, Thiruvananthapuram is named as 'Dr. Pisharoty Sonde' after the famous Indian physicist and meteorologist Dr. Pisharoth Rama Pisharoty. The indigenously developed low cost GPS Sondes can replace the existing non-GPS Sondes used for the meteorological applications.

3. Monitoring and data Analysis:

Aethalometer: The BC aerosol sampling was performed on the first floor of the Department of Applied Mathematics building of BIT Mesra, the BC mass concentration is estimated by measuring the change in transmittance of a quartz filter tape based on filtering of air. The instrument has been operated at a time base of 5 minute; round the clock with a flow rate of 4-liter min^{1}.The recorded data is downloaded and converted into hourly average after data cleaning.

The Aethalometer data has been studied for BC concentration over Ranchi for their characteristic variations, particularly diurnal and seasonal. The analysis is also done for different types of weather conditions like clear sky days, foggy days, rainy days and dusty days as well as weekdays & weekends. The mixing layer height co-relation with the BC concentration is being studied using Radiosonde.

4. Results And Discussions:

As our study area is Ranchi comes under northern India, BC concentrations are expected to primarily reflect the impact of vehicular sources apart from industrial emission and urban anthropogenic activities.

Diurnal variation of BC concentration during clear, foggy and rainy days:

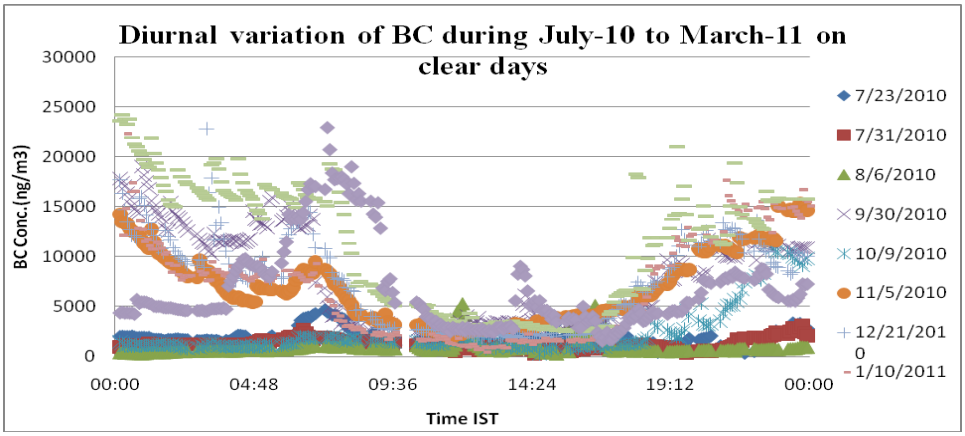


Fig.1 Diurnal variation of BC on very clear days during different months

Fig.1 Shows the diurnal variation of black carbon aerosols at Ranchi during July-10 to March-11 on selected few days. The concentration of BC is measured in nano gram per cubic meter (ng/m3) using the Aethalometer.Its reveals that BC concentration is high during morning and evening periods for all the days. The BC conc. shows enhancement during 06:30hr to 9:30hr and a decreasing trends afterwards till noon. The BC conc. remains almost constant till late noon and start increasing again at around 18:00 hr till midnight. During night time the BC conc. is high in comparison to daytime. During early morning hrs, high values of BC have been attributed due to fumigation effect within the boundary layer, which brings in aerosols from the nocturnal residual layer. Shortly after sunrise, the concentration stars decreasing. The peak around 8:30AM is due to morning traffic.Low values of BC during afternoon hours have been attributed to the dispersion of aerosols due to the turbulence caused by the solar heating which breaks the night time stable layer, and also due to increase in boundary layer height in addition to the low traffic density.

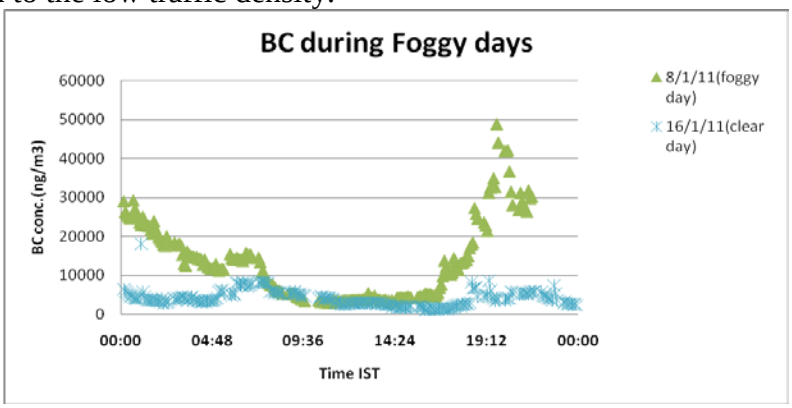


Fig.2 Diurnal variation of BC during foggy days

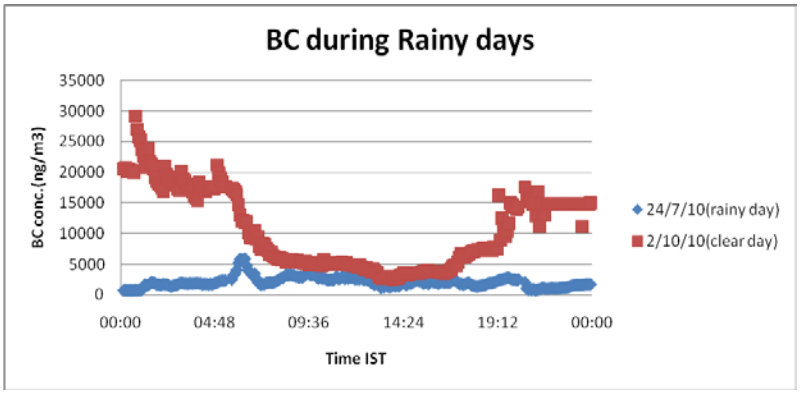


Fig.3 Diurnal variation of BC during rainy day

During foggy days (Figure.2) the concentration of BC is generally very high compared to the clear sky days. Moreover the high concentration lasts longer during the morning hours, generally till the fog lasts. On the other hand during rainy days the BC concentration is very low as the particles settle down due to rain.

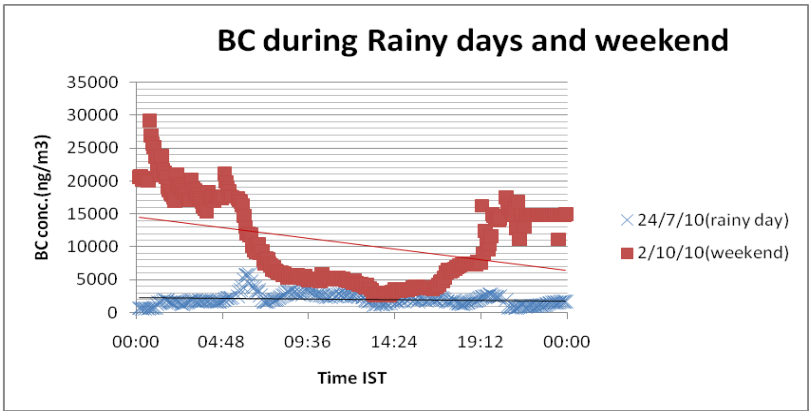


Fig.4 Comparative graph of BC during clear and rainy days.

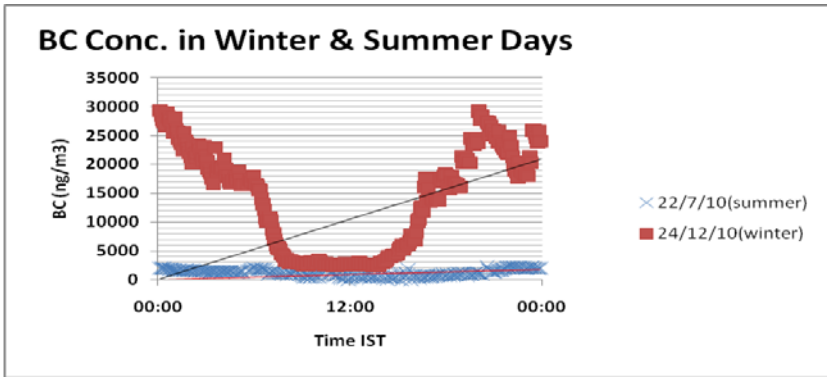


Fig.5 Comparative graph of BC during winter and summer days.

In Fig.4 a comparison of BC during clear and rainy days is done. The Peak value of BC during clear days reaches upto (~29154 ng/m3) at 00.45 hrs, while during rainy days it reaches only upto (~5748ng/m3) at 06:10 hrs.This may be attributed due to washout of BC due to rain. The BC Conc. Significantly reduces after rainfall due to scavenging process and also due due to reduction in the continental features conductive for aerosol generation by shifting the air mass(Latha and Badarinath,2005).During daytime from 12.30 to 17:30 hrs,high BC values are observed during rainy days in comparison to clear days; which may be due to cloud cover during rainy days in comparison to clear days; which may be due to cloud cover during rainy days because the boundary layer is reduced during rainy days. Similarly, a comparison of BC conc. During winter and summer months has been done (fig.5) which shows that winter season has much higher BC Concentration in comparison to summer season. The peak value of BC during winter season reaches upto (~29280ng/m3) at 00:10 hours while during summer season it reaches only upto (~2539ng/m3) at 10:30hrs.The minimum value during winter season reaches upto (~2419ng/m3) at 13:40hrs while during summer season it reaches upto (~5ng/m3) at 11:55 hrs.The fluctuation during winter night is more than summer night.

Diurnal and seasonal variation of PBL height:

1. Diurnal variation of PBL height on clear days:

Fig.6 shows the diurnal variation of Planetary Boundary Layer (PBL) height on very clear days over the study area. It reveals that the rapid lifting in PBL height more in summer than winter.

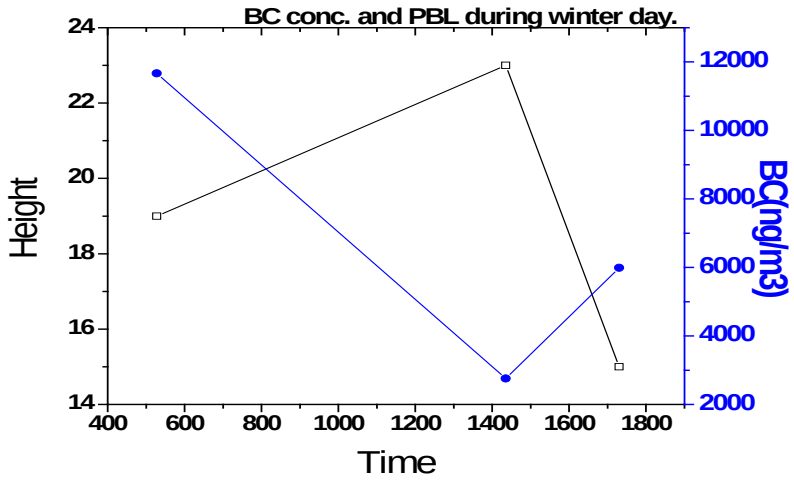


Fig.7 Comparative graph of BC and Planetary Boundary Layer (PBL) height during winter day (23/12/2010)

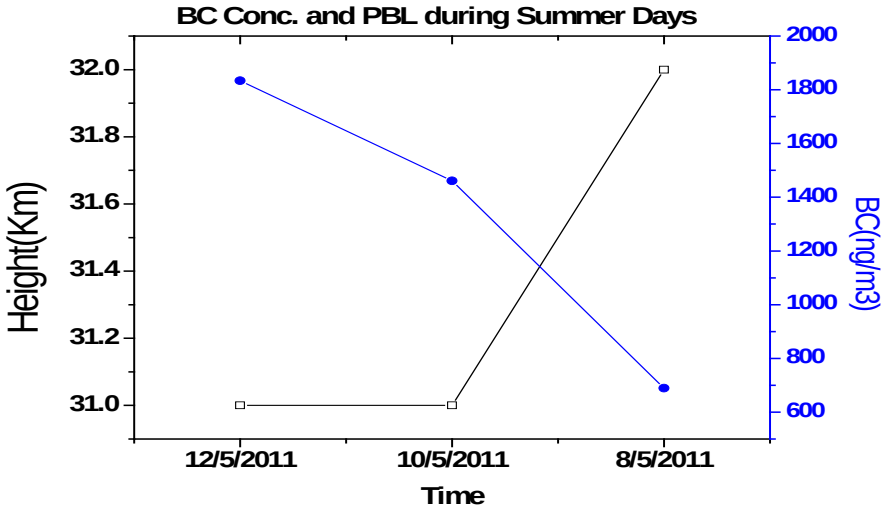


Fig.8 Comparative graph of BC and Planetary Boundary Layer (PBL) height during Summer days

Effect of PBL height on BC concentration:

In figure 7 and fig.8, the comparison of BC concentration has been done with the planetary layer height during winter and summer days respectively. In both the season the trend is almost similar. It depicts an inverse relationship between the BC concentration and the PBL.When mixing layer height starts increasing rapidly during morning hours after solar heating, BC concentration starts decreasing gradually and reaches to its minimum value (~410ng/m3 during summer season and ~780ng/m3 during winter season) around afternoon. During afternoon when BC conc. is minium, the PBL height increases to its maximum peak (25km during winter season and 31km during summer season).

The complete layer is convectly unstable and the mixing height within the layer dilutes the pollutants in addition to equalisation of temperature, humidity and other properties exists throughout the layer (Okey, 1987).The PBL height varies from 1 to 2km in early morning hours during winter and 1.5 to 4 km during summer while 1.3 to 2km in evening hrs during winter and 1.3 to 3.5 during summer.

Aerosol Optical Depth:

The column aerosol optical depth is measure of attenuation in solar radiation due to aerosols present on the total air column between sun and earth. High aerosol loading in the atmosphere will give rise to a high value of AOD, clean or pristine atmosphere will have a low AOD value.Fig.8 shows monthly variation of AOD at 550nm wavelength recorded using the Modis

satellite date during Jan. to December 2010. The AOD is generally highest during May-June and lowest during March. During May-June, several dust storms occurs in the western Indian region and the wind blown dust is highest over Ranchi causing a high value of AOD.Further,the high temperature during May-June(Summer) plays an important role in heating and lifting the loose soil with association of wind speed. In the month of March AOD is minimum as it is generally clean due to easterlies and minimum dust in the atmosphere.

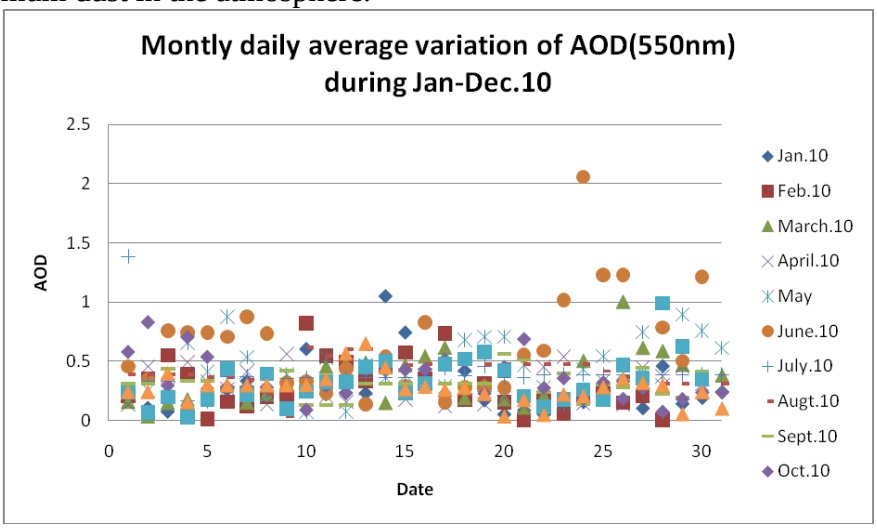


Fig.8, Monthly average variation of AOD during Jan-Dec.-10

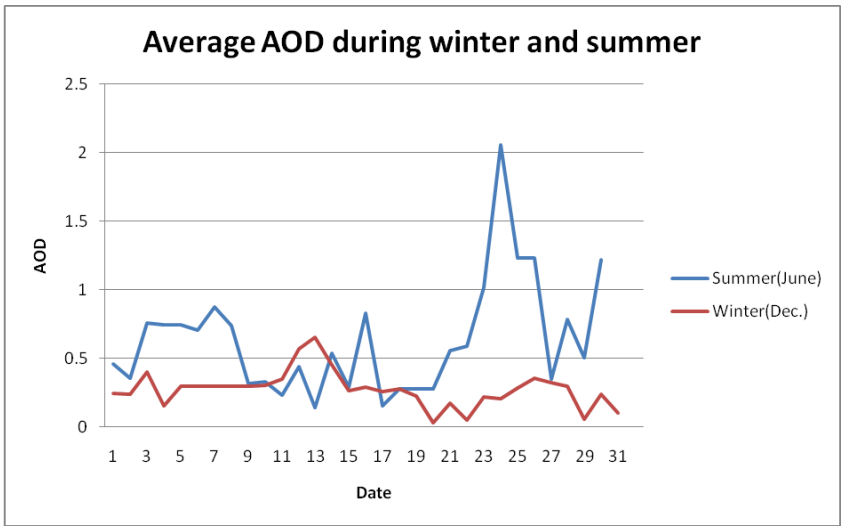


Fig. 9. Comparative graph of average AOD during winter and summer season

In the fig-2 average AOD during winter and summer has been shown at 550nm high value of AOD in summer than winter.

5. Conclusion

1. Diurnal variation of BC on clear days shows that high values of BC in this early morning 7:00 to 9:00h and a broad nocturnal peak from 21:00 to 1:00h.During foggy days, high concentration lasts longer during the morning hours, generally till the fog last. On the other hand during rainy days the BC the BC concentration is very low as the particles settle down due to rain.
2. Seasonal variation of BC aerosol showed high concentration during winter and low concentration during monsoon and summer season. Winter night shows more BC fluctuations in compared to summer night.
3. Monthly average BC values on hourly basis shows that morning BC peak value at 8:30 h during winter and 7:30h during summer and monsoon. Minimum BC value has been observed at around 15:30h for every month. During night there is no any fixed time for BC peak. The average BC conc. during winter morning (8:30h) has been observed ~6 times more than winter after noon (15:30h) whereas during summer morning (7:30h) ~3 times more than summer after noon (15:30h).
4. Seasonal variation of AOD suggests that during summer AOD values are more in compared to winter at 550nm wavelength.

Acknowledgement:

The authors express sincere gratitude to GBP Programme of Space Physics Laboratory for providing the required meteorological data from ARFI network and Birla Institute of Technology, Mesra, Ranchi for allowing me to work in its premises and providing the facilities and necessary data to main author.

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